R. geographicum DC. *f.*, *M.S.*
R. viridiatrum Koerb. *f.*, *M.S.*
R. petraeum Massal. *f.*, *M.*
R. confervoides DC. *f.*, *M.S.P.*
Lecanactis premnea Weddell *f.*, *H.*
L. abietina Koerb. *f.*, *H.*
Arthonia lurida Ach. *f.*, *S.D.*
A. gregaria Koerb. *f.*, *H.*
A. radiata Ach. *f.*, *H.*; var. Swartziana Sydow, *f.*, *H.*
Lithographa dendrographa Nyl. *f.*, *H.*
Opegrapha atra Pers. *f.*, common; var. denigrata Schaer. *f.*, *S.*
O. varia Pers. *f.*, *P.*
O. vulgata Ach. *f.*, *H.D.*; var. siderella Nyl. *f.*, *H.*
Graphis elegans Ach. *f.*, *P.D.*; f. coacervata Leight. *f.*, *H.*
G. scripta Ach. *f.*, *H.*
Phaeographis inusta Muell.-Arg. *f.*, *H.*
P. dendritica Muell.-Arg. *f.*, *D.*
Enterographa crassa Fée *f.*, *D.*
Dermatocarpum aquaticum A. Zahlbr. *f.*, *H.S.*
Verrucaria maura Wahlenb. *f.*, *M.*
V. aquatilis Mudd *f.*, *D.*
V. margacea Wahlenb. *f.*, *P.*
V. submersa Schaer. *f.*, *H.P.*
V. viridula Ach. *f.*, *P.D.*
V. nigrescens Pers. *f.*, *H.*
V. glaucina Ach. *f.*, *M.*
V. maculiformis Krempelh. *f.*, *M.*
V. muralis Ach. *f.*, *P.*
Thelidium Nylanderi Krempelh. *f.*, *P.*
Acrocordia gemmata Koerb. *f.*, *H.P.*
A. biformis Oliv. *f.*, *H.S.*
A. epipolaea A. L. Sm. *f.*, *P.*
Arthopyrenia epidermidis Mudd *f.*, *H.P.*
A. punctiformis Arn. *f.*, *M.*
A. fallax Arn. *f.*, *H.P.*
Porina carpinea A. Zahlbr. *f.*, *P.*
Pyrenula nitida Ach. *f.*, *H.S.D.*

The following Fungus parasites were found on Lichens:

Ticothecium erraticum Massal. on Lecanora cinerea *M.*
Ticothecium rimosicolum Arn. on Rhizocarpum petraeum *M.*
Spegazzinia sp. on Pertusaria dealbata *S.*

PRESIDENTIAL ADDRESS.

By T. Petch, B.A., B.Sc.

FUNGI PARASITIC ON SCALE INSECTS*.

The earliest record of a fungus parasitic on a scale insect was made by Desmazières in 1848†. His specimens were collected at Caen, in Normandy, growing on scale insects on willow and ash. He instituted for it a new genus, *Microcera*, and gave a fairly complete description, emphasising the fact that the fungus was enclosed in a veil or sheath which divided into teeth at the apex. *Microcera* may be said to be a *Stilbum*, which has Fusarioid conidia, and is enclosed in a sheath which partly envelopes the head of conidia. Desmazières was so impressed by the structure and habitat of his species that he added to the formal description a long account of it in which he allowed his imagination free rein and compared *Microcera* to a phalloid.

Desmazières' species was next described by the Tulasnes in

* From the mycological standpoint, it is convenient to include the fungi parasitic on Aleyrodidae with those on the true scale insects (Coccidae).

† Ann. Sci. Nat., Ser. 3, 1. (1848), p. 359.

1861*. They did not find the universal veil, and stated that the apparent veil was merely a covering of mycelium at the base of the stroma. It would seem that they were misled by Desmazières' use of the term volva, and his comparison with a phalloid, and expected to find a structure resembling a phalloid volva at the base of the clava. It is difficult to make out the structure of *Microcera* from European examples.

Desmazières' fungus, *Microcera coccophila*, was a conidial form. To it the Tulasnes attached a perithecial stage, which was collected in company with a similar conidial stage at Florence. The perithecial stage was a *Nectria*, and consequently the Tulasnes placed the fungus in their genus *Sphaerostilbe*, under the name *Sphaerostilbe coccophila*. It is to be noted that the type locality for the perithecial stage is Florence, Italy, and that of the conidial stage, Caen, France.

The next record of a *Nectria* on a scale insect was made by Berkeley and Broome in the Fungi of Ceylon (1873)†, in which they described *Nectria aurantiicola*, with the note, "apparently growing from some coccus." Berkeley and Broome described the Fusarioid conidia and figured the effete Stilboid stage dividing into teeth at the apex; consequently, one is rather at a loss to understand why they did not place their species in *Sphaerostilbe*.

Two years later‡, Berkeley and Curtis described *Nectria aglaothele* from North America, with a note that it grew on the remains of a coccus. This again is *Sphaerostilbe*.

In 1901, Zimmermann described *Nectria coccidophthora*§, on scale insects in Java. This differs from *Nectria aurantiicola*, principally in its larger ascospores, and must be classed with the latter species in *Sphaerostilbe*.

So far the record is quite straightforward. Four species referable to *Sphaerostilbe* have been described as occurring on scale insects. But naturally, the idea that fungi might be parasitic on scale insects, and not on the plant on which they were found, was not always in mind, and hence it is only to be expected that, when the presence of the scale insect was not immediately obvious, such fungi would be described without reference to their real host. An examination of the species of *Nectria* and *Sphaerostilbe* in the herbaria at Kew and the British Museum has confirmed that supposition.

Prior to *Sphaerostilbe coccophila*, the Tulasnes had described a species with a similar conidial stage as *Sphaerostilbe flammea*. The history of the latter species begins in England, with speci-

* Selecta Fungorum Carpologia, I, p. 130; III, p. 105.
† Journ. Linn. Soc. XIV (1873), p. 117.
‡ Grevillea, IV (1875), p. 45.
§ Centralb. f. Bakt., Abt. II, VII (1901), p. 873.

mens collected by Ralfs at Penzance on living willows. These were described by Berkeley in 1854 as *Atractium flammeum* Berk. and Rav.*, the fungus having been found in similar situations, peeping up from beneath lichens, by Ravenel in South Carolina. Berkeley noted that Ravenel suspected it to be the state of some *Nectria*, and the herbarium specimens show that Ravenel had suggested that it was a stage of *Nectria muscivora* B. and Br.

Nectria muscivora was described by Berkeley and Broome† in 1851. It was parasitic on mosses at Kings Cliffe. To the description they added the note that they had the species from South Carolina on *Jungermannia*. There is an abundance of American specimens from Ravenel available in Herb. B.M. and Herb. Kew, under *Nectria muscivora*, and also others of the same species, either conidial, or conidial and perithecial, under *Atractium flammeum*, *Sphaerostilbe flammea*, and *Microcera coccophila*, identified by Berkeley or Ravenel.

Berkeley sent specimens of *Atractium flammeum* to the Tulasnes, and these proved to bear *Nectria* perithecia. Consequently the Tulasnes described it, first under the name *Stilbum flammeum*‡, and later as *Sphaerostilbe flammea*§. According to the Tulasnes, the specimens sent to them were American, though they stated that they grew on willow, which was the English host plant. Here we have another case in which the type locality for the conidial stage is in one country and the type locality for the perithecial stage in another.

This species was described again as *Nectria laeticolor* by Berkeley and Curtis in 1868‖; as *Nectria aglaothele* by the same authors in 1875¶, as *Nectria subcoccinea* by Saccardo and Ellis in 1882**, and as *Nectria Passeriniana* by Cooke in 1884††.

Ellis and Everhart discovered that *Nectria subcoccinea* was the same as Ravenel's specimens which had been attributed to *Nectria muscivora*, and they drew up their description of the latter species from specimens which had been distributed by Ellis as *Nectria subcoccinea*‡‡. But they did not see Berkeley and Broome's type of *Nectria muscivora*, and consequently were unaware that the original determination of Ravenel's specimens as *Nectria muscivora* was incorrect. That leaves *Sphaerostilbe flammea* as the earliest name for Ravenel's species, which is

* Ann. Mag. Nat. Hist., Ser. II, XIII (1854), p. 461.
† Ann. Mag. Nat. Hist., Ser. II, VII (1851), p. 188.
‡ Acta Hebdom. Acad. Sci. par. XLII, p. 704, and Ann. Sci. Nat., Ser. 4, V (1856), p. 114.
§ Selecta Fung. Carp. I, p. 130; III, p. 104.
‖ Journ. Linn. Soc. X, p. 377 (1868).
¶ Grevillea, IV (1875), p. 45.
** Michelia, II (1882), p. 570.
†† Grevillea, XII (1884), p. 81.
‡‡ North American Pyrenomycetes (1892).

not parasitic on mosses and lichens, but on scale insects which in some instances occur beneath mosses and lichens.

We have now to reconsider the species which has always been recognised to be parasitic on scale insects, viz. *Sphaerostilbe coccophila* Tul. This, it will be remembered, was instituted on a conidial stage, *Microcera coccophila*, collected in Normandy and a perithecial stage collected in Italy. Specimens of both these collections are available, and in both cases they contain perithecia. But the perithecia which accompany *Microcera coccophila* are not the same as those collected in Italy. The former are the perithecia of *Sphaerostilbe flammea*, while the latter are the species described from Ceylon by Berkeley and Broome as *Nectria aurantiicola*. Consequently *Microcera coccophila* Desm. is the conidial stage of *Sphaerostilbe flammea*, and *Atractium flammeum* is a synonym, while Tulasnes' *Sphaerostilbe coccophila* consists of the perithecia of one species and the conidial stage of another.

One has considerable hesitation in proposing to abolish a name which has become so firmly established in the literature of economic mycology. But *Sphaerostilbe coccophila* is a compound species and its name was admittedly selected on the mistaken supposition that the perithecia described were related to *Microcera coccophila*. In any case, *Microcera coccophila* must be retained for the conidial stage of *Sphaerostilbe flammea*, and it would be very confusing to retain the same specific name for the perithecial stage of a different *Sphaerostilbe*.

We have therefore three species of *Sphaerostilbe* parasitic on scale insects, viz. *Sphaerostilbe flammea, Sphaerostilbe aurantiicola*, and *Sphaerostilbe coccidophthora*. In their conidial, *Microcera*, stages, these are all very similar and it is scarcely possible to define any constant distinguishing characters. But their perithecia are sufficiently distinct to maintain them as different species.

Species of *Sphaerostilbe* on scale insects would appear to be rare in Europe. The European material available in English herbaria is fairly abundant, but it is the product of very few gatherings. Perhaps the position may be similar to that of *Hypocrella* and *Aschersonia* in the Tropics, i.e. the fungus only required to be looked for. Moreover, to one who has collected *Sphaerostilbe* on scale insects in the Tropics, all the temperate collections appear very poorly developed, especially as regards the *Microcera* stage. *Microcera coccophila* in Europe and the Northern United States usually does not exceed half a millimetre in height, but in the type of *Microcera pluriseptata* from Brazil, which is identical with *Microcera coccophila*, the synnemata attain a height of 2·5 mm.; and the same difference is

seen between *Microcera aurantiicola* from Italy and Ceylon respectively. One gains the impression that the temperate gatherings are depauperate examples of species which have wandered out of their proper latitude.

According to the specimens which I have been able to examine, the distribution of these species of *Sphaerostilbe* is as follows.

Sphaerostilbe flammea is chiefly an American species. It has been found in the United States—Massachusetts, Pennsylvania, Georgia, South Carolina, Louisiana, Florida and Texas—in Cuba, Brazil, and Argentina; in England, in the neighbourhood of Penzance; in Normandy in France; and in Liguria in Italy (*Nectria Passeriniana*). Conidial specimens from South Africa, Australia, and New Zealand appear to belong to this species but no perithecia are available; the first of these were described as *Fusarium coccinellum* (Kalch.) Thuem.*

Sphaerostilbe aurantiicola would appear to be the common species of the tropics, extending occasionally into temperate countries. I have examined specimens from Ceylon, India, Formosa, Japan, Madagascar, the West Indies, Georgia, Florida, and Italy.

Sphaerostilbe coccidophthora is at present known only from Java, Ceylon, India, and the Seychelles.

In general, these species of *Sphaerostilbe* are parasitic on *Lepidosaphes* (*Mytilaspis*), *Aspidiotus*, *Parlatoria*, *Diaspis*, *Chionaspis*, and allied genera of scale insects. They frequently occur on scale insects on Citrus, and it is to be expected that their natural distribution will have been extended by the transference of Citrus plants and fruits from one country to another.

Records of *Microcera coccophila*, and of *Microcera* in general, must all be regarded with caution, for the name *Microcera* has been employed to cover any conidial fungus with *Fusarium* spores which grew on a scale insect. One cannot, however, examine many gatherings of these conidial fungi before discovering that there are two common types which differ generically from one another. That fact was noted by Parkin† who characterised the difference by stating that the one form possessed an adherent sheath, while the other had a loose sheath. But Parkin, not having seen the European *Microcera*, referred the first of these, which is the true *Microcera*, to *Fusarium*, and the second to *Microcera*.

Microcera, in well-developed examples, has a *Stilbum*-like stalk composed of parallel hyphae, which separate at the apex, branch, and bear *Fusarium* conidia; the outer hyphae of the stalk are united into a continuous sheath, which is adherent to

* Thuemen, Mycotheca Universalis, No. 782.
† Annals R.B.G. Peradeniya, III (1906), p. 52.

the stalk, but separates into teeth and becomes free round the head of conidia; the sheath is inconspicuous, except after the conidia have been dispersed. The fructification is a synnema, and the genus falls in the *Stilbaceae*.

In the common form which has been confused with *Microcera*, the base of the fructification, in well-developed forms, is parenchymatous, and forms a more or less oval, red, cushion; at the upper edge of this there arises a ring of white teeth, like the margin of a Discomycete, but connivent, surrounding the apex of the cushion; the apex of the cushion bears closely packed conidiophores which produce *Fusarium* conidia. In this form, the sheath contrasts strongly with the base and, as a rule, is the most conspicuous feature of the fungus; it is not continuous with the basal cushion and differs in structure from the latter. The conidia of this form differ in shape from those of the species of *Microcera* which are parasitic on scale insects. This fructification must be classed in the *Tuberculariaceae*.

I have examined specimens of this form from Ceylon, India, Burma, Java, Mauritius, Australia, Formosa, the Philippines, West Africa, Grenada, Cuba, Florida, and Brazil. It has occurred on *Mytilaspis*, *Aspidiotus*, *Ischnaspis*, *Fiorinia*, and *Aonidia*. There are no constant differences between the specimens from different localities or on different scale insects, but the available specimens from West Africa have much longer conidia than those from other countries. As, however, the specimens, with few exceptions, are conidial only, it is perhaps advisable to regard the species as possibly a collective one. In America it has been referred to *Microcera coccophila*; in Formosa it has been named *Microcera Fujikuroi**; and from the Philippines, *Microcera Merrillii*†. As it is a common fungus, it is quite probable that it was named in the earlier days of mycology, without reference to its habitat. The earliest name yet discovered is that given it by Koorders in Java, viz. *Aschersonia Henningsii*‡. I propose to establish for this species a new genus, *Pseudomicrocera*, in which it will stand as *Pseudomicrocera Henningsii*.

In 1886 (?) Spegazzini described a *Nectria* which occurred on scale insects in Brazil as *Nectria coccorum*§, and in 1889, a second species, *Nectria coccogena*‖, from the same country. Through the kindness of Professor Spegazzini, I have been able

* Journ. Coll. Agric., Tohuku Imp. Univ., Sapporo, v, pt. 3 (March 1913), pp. 73–90.

† Ann. Myc. xii (1914), p. 576. ‡ Bot. Untersuchungen (1907), p. 213.

§ Fungi Guaranitici, Pug. i, No. 234, Anal. Soc. Cientif. Argentina, Buenos Aires.

‖ Fungi Puiggariani, No. 289, Bolet. de la Acad. Nacional de Ciencias de Cordoba, ii (1889), p. 381.

to examine the type specimens of both these species; that of *Nectria coccorum* is immature, but it appears to me to be identical with *Nectria coccogena*. Both the type specimens show a *Pseudomicrocera* conidial stage which is identical with *Pseudomicrocera Henningsii*. In Ceylon, this *Nectria* has been collected on two occasions, in each case developing on the old stromata of *Pseudomicrocera Henningsii*, and I have an immature gathering from Mauritius. *Pseudomicrocera Henningsii*, therefore, is the conidial stage of a *Nectria*. But the earliest name yet discovered for this *Nectria* is *Nectria diploa* B. and C., which was given to specimens from Cuba in 1875.

In 1901, Nomura published a paper* on the Scarlet Fungus Disease of Scale Insects in Japan, describing the fungus as a new species, *Nectria coccophila*. His paper was written in Japanese and has been generally overlooked, but in 1913 it was summarised by Miyabe and Sawada in their account of the fungi parasitic on scale insects in Formosa. Nomura, apparently, did not leave any type specimen, and the identity of his species is uncertain. Miyabe and Sawada would appear to favour the view that it was the species which they assign to *Sphaerostilbe coccophila*, but Nomura's description agrees more closely with *Nectria diploa*.

In 1913, Sydow† described a new genus and species parasitic on a scale insect in Japan as *Coccidophthora variabilis*. Subsequently K. Hara‡, who had sent the fungus to Sydow, stated that the specimen consisted of two species, viz. a *Nectria* parasitic on the scale insect, and a second species parasitic on the *Nectria*, and he described the scale insect *Nectria* as *Nectria variabilis*. I have not been able to examine a specimen of this *Nectria*, but from the published figures and the description it would appear to be again *Nectria diploa*.

A number of species have been described as *Microcera*, nine of which were said to be parasitic on scale insects. It is evident that the genus requires revision from the systematic standpoint, but at present only the scale insect species have been critically examined. Fortunately, most of the types of the latter have been available.

In 1904, McAlpine described§ two species of *Microcera* parasitic on scale insects in Australia, viz. *Microcera tasmaniensis* and *Microcera Mytilaspis*. The types of these species have been kindly lent me by Mr C. C. Brittlebank, and examination shows that they are identical, the first being a younger development of the second. This species proves to be neither *Microcera* nor

* Imp. Agric. Exp. Sta., Rep. 18 (1901), p. 105.
† Ann. Myc., XI (1913), p. 263.
‡ Botanical Magazine, Tokyo, XXVIII (1914), p. 339.
§ Agric. Journ. Victoria, II (1904), pp. 646–648.

Pseudomicrocera. It consists, in its fully developed form, of a stalked pezizoid disc, which bears *Fusarium* conidia. I propose to make this the type of a new genus, *Discofusarium*, with the species *Discofusarium tasmaniense*. Mr Brittlebank has also furnished me with specimens which show that the perithecial stage of this species is a *Calonectria*.

Of the remaining species of *Microcera*, parasitic on scale insects, *Microcera Parlatoriae* Trabut*, *Microcera Tonduzii* Pat.†, and *Microcera curta* Sacc.‡ are *Fusarium*. *Microcera rectispora* Cooke and Massee§ is *Tetracrium*, the conidial stage of *Ophionectria* (? *coccicola*); Cooke protested‖ that he made this species only in deference to the current opinion that minute differences in the spores were specific, but it would be difficult to imagine anything more different from *Microcera* than this.

In 1918, Stevenson¶ described another type of conidial fungus, *Tubercularia coccicola*, which was found on scale insects, *Lepidosaphes* and *Hemichionaspis*, in Porto Rico. Specimens have been kindly furnished by Stevenson, and they are, as far as can be determined, identical with a similar conidial fungus which occurs on scale insects in Ceylon and India. In the two latter countries, however, the perithecial stage has been found, and this, as might be expected, is another species of *Nectria*, which will be named *Nectria Tuberculariae*.

Another undescribed species of *Nectria* has been found on *Mytilaspis* on *Citrus* in Ceylon. This will be described as *Nectria barbata*. Its conidial stage is unknown.

Historical sequence has been discarded in this account, in order to bring together the recorded species of the same genus. We must now go back to 1886, when Ellis and Everhart** described a species, parasitic on scale insects on orange trees in Florida, as *Ophionectria coccicola*. Ellis and Everhart dealt with the perithecial stage only; Zimmermann††, who found the same species on *Parlatoria* in Java, supplied a description of the conidial stage in 1901. This conidial form is a very curious production. It consists of a short parenchymatous column, surmounted by a white, usually conical, head of conidia. The conidiophores are short moniliform chains of a few cells. At the apex, each conidiophore bears a cluster of two to five, long, lanceolate conidia, which falls off as a whole. The detached conidium is compound, and consists of a basal cell, the apical

* Bull. Agric. Alger et Tunisie, 1907, p. 32.
† Bull. Soc. Myc. France, XXVIII (1912), p. 142.
‡ Ann. Myc., VII (1909), p. 437. § Grevillea, XVI (1888), p. 4.
‖ Vegetable Wasps and Plant Worms, 1892.
¶ Annual Rep., Insular Exp. Sta., Porto Rico for 1917.
** Journ. Myc., II (1886), p. 39; *ibid.*, p. 137.
†† Centralb. f. Bakt., Abt. 2, VII (1901), p. 872.

cell of the conidiophore, from which arise from two to five long, lanceolate arms. There are usually three arms, and the whole conidium resembles the print of a bird's foot. It has been stated that the arms close up when the conidium dries, and expand again when it is wetted, so that the spore is propelled along the surface of a leaf, but I have not been able to observe that effect.

In 1902, Hennings* found a similar conidial fungus on scale insects on orange from Brazil and instituted for it a new genus, with the species *Tetracrium Aurantii*. Later, von Höhnel† re-examined Henning's specimen and discovered perithecia on it, of the same structure as *Ophionectria coccicola*. But he placed his species in the genus *Puttemansia* and transferred Ellis and Everhart's species to the same genus.

In 1910, Massee‡ described a scale insect fungus from Trinidad as *Scleroderris gigaspora*. No type specimen is available, but it is agreed that this was *Ophionectria coccicola*.

In 1913, Miyabe and Sawada§ described *Ophionectria tetraspora* on *Parlatoria* from Formosa. I have examined a specimen of this from Formosa, and it appears to me to agree with von Höhnel's description of *Puttemansia Aurantii*, but I have not seen the type of the latter.

A third species, co-generic with *Ophionectria coccicola*, has recently been found in Ceylon.

Puttemansia Aurantii is at present known only from Brazil and Formosa. *Ophionectria coccicola* is a widely distributed species, and I have seen specimens from Ceylon, Formosa, South Africa, Florida, and Dominica (W.I.), while it has been recorded correctly from Java. These species have occurred on scale insects belonging to the genera *Parlatoria*, *Aspidiotus*, and *Lepidosaphes* (*Mytilaspis*).

Ellis and Everhart placed their species in *Ophionectria*. Seaver transferred it to a recently-instituted genus, *Scoleconectria*‖. Von Höhnel considers that it belongs to *Puttemansia*, which is a genus founded by Hennings for a fungus he thought was a Discomycete. Consequently the nomenclature question has become somewhat complicated. It will be discussed fully in a later paper. But the three species of *Ophionectria*, *Scoleconectria*, or *Puttemansia* which are parasitic on scale insects agree with one another in having a *Tetracrium* conidial stage. Consequently, as far as these species are concerned, the simplest way of escape from the maze of nomenclature is to institute

* Hedwigia, XLI (1902), p. 116.
† Fragmente zur Mykologie, XIII (1911), pp. 27–30.
‡ Kew Bulletin, 1910, p. 3.
§ Journ. Coll. Agric., Tohuku Imp. Univ., Sapporo, V (1913), p. 85.
‖ Mycologia, I (1909), p. 198.

for them a new genus characterised by the possession of multiseptate ascospores and a *Tetracrium* conidial stage. It may be objected that genera of ascigerous fungi should not be founded on conidial characters, but we have a parallel case in *Sphaerostilbe*, which is merely a *Nectria* with a Stilboid conidial stage. For this new genus, I propose the name *Podonectria*, the species being *Podonectria coccicola* (E. and E.), *Podonectria Aurantii* (v. H.), and *Podonectria echinata*.

Zimmermann*, in his paper on scale insect fungi found in Java (1901), described *Lisea Parlatoriae* on *Parlatoria*, and *Broomella Ichnaspidis* on *Ichnaspis*. I have not met with any species of either of these genera on scale insects. From Zimmermann's description and figure, it is clear that the second of these is not a *Broomella*.

Among the fungi so excellently figured by the Tulasnes†, there is one, *Melanospora parasitica*, the nature of whose parasitism is doubtful. It is generally supposed to be parasitic on entomogenous fungi, and has been recorded on *Isaria*, on *Botrytis Bassiana*, and on *Cordyceps militaris*. But the Tulasnes figure it growing on a cockchafer, and it has been recorded as parasitic on *Lecanium hemisphaericum* in India‡. It has been found on *Icerya Purchasi* in Ceylon; in the latter country, it often occurs with *Cephalosporium*, but in several cases it appears to have attacked the insect independently of any other fungus.

In the genera, which are more usually associated with insects, viz. *Cordyceps* and *Torrubiella*, the number of species recorded as occurring on scale insects is comparatively small. In *Torrubiella* there are four species: *Torrubiella rubra* Pat. and Lagh.§, from Ecuador (1893), *Torrubiella luteorostrata* Zimm.*, from Java (1901), *Torrubiella brunnea* v. Keissl.‖, from Samoa (1909), and *Torrubiella Lecanii* Johnston¶ from Cuba (1918). In the case of the first three the species of scale insect is not recorded. Two species have been collected in Ceylon, on *Aleyrodes*, and Parkin** recorded a gathering on *Aspidiotus*. This genus has not yet been revised.

In the case of the genus *Cordyceps*, three species are said to occur on scale insects, but very little is known about two of them. In 1861, Berkeley and Broome described *Cordyceps pistillariaeformis*††, growing on a scale insect, apparently a *Lecanium*, on Wych Elm at Batheaston. Apparently only two

* Centralb. f. Bakt., Abt. 2, VII (1901), p. 872.
† Selecta Fungorum Carpologia. ‡ Ann. Myc., IX (1911), p. 392.
§ Bull. Soc. Myc. France, IX (1893), p. 154.
‖ Micromycetes in Bot. u. Zool. Ergebnisse, Samoa Inseln, von Karl Rechinger.
¶ Mem. Soc. Cubana Hist. Nat. "Felipe Poey," III (1918), p. 80.
** Ann. R.B.G. Peradeniya, III (1906), pp. 18, 19.
†† Ann. Mag. Nat. Hist., Ser. 3, VII (1861), p. 451.

specimens were found, one conidial, and the other perithecial, but immature. From the herbarium collections, this species does not appear to have been found again in Britain. Prior to that, in 1834, Schweinitz had described *Sphaeria clavulata* in his Synopsis of North American fungi*. In 1869, when Berkeley and Curtis enumerated the fungi of Cuba†, they listed *Sphaeria clavulata* as a *Xylaria*, adding the extra-Cuban localities, North America and Venezuela. Subsequently, Peck stated that Schweinitz' *Sphaeria clavulata* was a *Torrubia*‡, or, as we should now call it, a *Cordyceps*, and Ellis and Everhart§ state that it is quite certain that the *Cordyceps* distributed by Peck is the genuine *Sphaeria clavulata*. It has been collected in America on several occasions, and is parasitic on *Lecanium*. Cooke‖ considered that *Cordyceps pistillariaeformis* B. and Br. is identical with *Cordyceps clavulata* (Schw.) E. and E., and Massee, Ann. Bot. IX (1895), p. 22, agreed with him. That view is most probably correct, but one would wish for further material of the British species before coming to a final decision. The herbarium specimens show some differences, which may however prove to be intraspecific. Berkeley's specimen of *Xylaria clavulata* from Cuba is a very immature *Xylaria*, and has little resemblance to *Cordyceps clavulata*.

The other species of *Cordyceps*, said to occur on a scale insect, is *Cordyceps coccigena* (Tul.) Sacc.¶, described and figured by the Tulasnes. It was collected in New Guinea, and was said to be growing on a coccus. As in the case of so many collections of these entomogenous fungi it was immature. However, from the excellent illustration, one is led to doubt the statement that it was growing on a coccus. The insect is large for a scale insect, and the figure shows that the body consisted of at least two distinct segments. Two clavae, with depressed globose heads, arise from the foremost segment. Except that the anterior segment is covered with mycelium, the illustration is good for *Cordyceps dipterigena* B. and Br., and I would hazard the suggestion that *Cordyceps coccigena* really grew on a fly.

In the case of the species which have already been mentioned, there is usually no doubt that the fungus is growing on a scale insect. It does not obliterate the insect. It generally grows out from the insect and produces its conidiophores at the margin of the scale and its perithecia in the same position or on the top of the scale. In *Podonectria*, there is a byssoid stroma

* Trans. American Philos. Soc., IV (1834), pp. 141–316.
† Journ. Linn. Soc., X (1869), p. 380.
‡ 28th Rep. New York State Museum.
§ North American Pyrenomycetes.
‖ Vegetable Wasps and Plant Worms, 1892.
¶ Selecta Fungorum Carpologia, III, p. 19, Tab. I, fig. 10.

which may spread over several scales, and in *Torrubiella* a similar stroma may cover the greater part of a colony of insects, but the scales are usually clearly evident. In the largest group of scale insect fungi, however, conditions are different; in it, each individual fungus grows over a single insect, and, as a rule, not only hides it completely, but consumes the whole of it, so that there is no trace of the insect left within the stroma. Therefore, it is not surprising that the first fungi recorded as parasitic on scale insects belonged to the *Sphaerostilbe* or *Nectria* group, while the species of the larger group, *Hypocrella* and *Aschersonia*, were described without reference to any host, except the plants on which they occurred.

The genus *Aschersonia* was founded by Montagne* in 1848 for two species, supposed to be phyllogenous, one from Guiana and the other from Tahiti. They were pycnidial fungi, brightly coloured, and evidently allied to the *Hypocreaceae*. In 1884, Saccardo† enumerated nine species; by the year 1900, the number had increased to 26; and at the end of 1919, there were 60.

It was not discovered that species of *Aschersonia* were entomogenous until 1894, when Webber‡, who had studied the fungi and insects which occurred on *Citrus* in Florida, demonstrated that *Aschersonia aleyrodis* was parasitic on *Aleyrodes citri* R. and H., *Aschersonia turbinata* on *Ceroplastes floridensis*, and, judging from his figures, *Aschersonia cubensis* on *Lecanium hesperidum* L. Webber suggested that all species of *Aschersonia* would be found to be entomogenous, but his results did not have any immediate influence on systematic mycology. Hennings§ described five species of *Aschersonia* from Java in 1902, and called attention to the remarkable phenomenon that these fungi generally occurred with various species of *Lecanium*, to which they bore so great a resemblance in form and colour that he considered the association should be regarded as a case of mimicry. Parkin‖, in 1906, supported Webber's view, and recorded eight gatherings of *Aschersonia* parasitic on *Aleyrodes* and seven gatherings on *Lecanium*; from the specimens left by him, these included *Aschersonia placenta*, *Aschersonia confluens*, *Aschersonia hypocreoidea*, and *Aschersonia samoensis*, on *Aleyrodes*, and *Aschersonia Coffeae* and *Aschersonia marginata* on *Lecanium*. Since 1904, new species of *Aschersonia* have generally been described as occurring on scale insects or *Aleyrodidae*; and at the present time, all species which are true *Aschersonia* in structure are known to be entomogenous.

* Ann. Sci. Nat., Ser. 3, x, p. 122. † Sylloge Fungorum, III, p. 619.
‡ U.S.A. Dept. Agric., Div. Veg. Physiol. and Pathol., Bull. 13 (1897).
§ Hedwigia, XLI (1902), pp. 145, 146. ‖ *Op. cit., supra.*

Species of *Sphaerostilbe* and *Nectria* attack *Lepidosaphes* (*Mytilaspis*), *Chionaspis*, *Aspidiotus*, *Fiorinia*, and allied insects. Species of *Aschersonia*, on the other hand, attack only insects belonging to the families *Lecaniidae* and *Aleyrodidae*. Moreover, there is a notable difference between the species parasitic on the two families respectively: those parasitic on *Aleyrodidae* have paraphyses in the pycnidium, while those parasitic on *Lecaniidae* have no paraphyses. It is curious that of Montagne's two species, *Aschersonia taitensis* is aleyrodiicolous, while *Aschersonia guianensis* is lecaniicolous.

The perithecial stage of *Aschersonia* is *Hypocrella*, and as might be expected, it also is entomogenous. The earlier mycologists included species of *Hypocrella* in *Hypocrea*, from which it differs in having long filiform spores which divide into rod-shaped, or oval, part-spores in the ascus. *Hypocrella* was split off in 1878 by Saccardo*, who placed in it four species, only one of which, the type species, now remains in the genus. Ten species were enumerated by Saccardo† in 1883, but the number described up to the end of 1919 is seventy (including *Fleischeria* and *Moelleriella*).

In general, species of *Hypocrella* so closely resemble the corresponding species of *Aschersonia* that it is not possible to decide which a given stroma is without sectioning it. Yet it was apparently not until 1896 that any relationship between the two was suggested. In that year, Massee‡ stated that he had examined Berkeley's specimen of *Aschersonia oxyspora* and found that it was a *Hypocrella*, Berkeley having mistaken the part spores for *Aschersonia* spores. He had also examined part of Montagne's type of *Aschersonia taitensis*, the type species of the genus, and had found that the young stromata were covered with a dense stratum of fusiform spores while "the primordia of perithecia were very evident in the substance of the stroma." Hence he suggested that "in all probability the genus *Aschersonia* will prove to be nothing more than the conidial form of *Hypocrella*."

I have not been able to trace any further observations on this point by Massee, but three years later, in his Textbook of Plant Diseases (1899), he wrote, "I have shown that species of *Aschersonia*, which hitherto were only known to produce a conidial form of reproduction on living leaves, produce an ascigerous form of fruit, following the conidial stage, on fallen dead leaves."

Massee's hypothesis, that *Aschersonia* is the pycnidial stage of *Hypocrella*, is undoubtedly true, but the observations which

* Michelia, I, p. 322.
† Sylloge Fungorum, II, p. 579.
‡ Journ. of Botany (1896), p. 151.

he cited in support of it are not correct. *Aschersonia oxyspora* Berk. is an *Aschersonia*, and its *Hypocrella* stage was unknown until recently collected in Ceylon. In *Aschersonia taitensis*, the stromata are not covered with spores; they bear discontinuous spore masses which have oozed out of the pycnidia, and the supposed primordia of the perithecia are the pycnidia in which they were produced. Moreover, no case is known in which the pycnidial form is followed by the development of an ascigerous form on dead fallen leaves. When the leaf falls, the fungus decays.

In general, an *Aschersonia* stroma does not subsequently become perithecial. Exceptions to that rule may be found in *Aschersonia turbinata* and *Aschersonia placenta*. But effete *Aschersonia* stromata usually decay, even when on living leaves, or stems. In some gatherings, all the stromata will be *Aschersonia*, in others all *Hypocrella*, and it has not yet been possible to determine what conditions govern the production of either stage. Just as, in *Sphaerostilbe*, the *Microcera* stage is commoner than the *Nectria* stage, so the *Aschersonia* stage is much more frequent than the *Hypocrella* stage.

How, then, is it possible to correlate species of *Aschersonia* with their *Hypocrella* stages? Simply by finding, as Massee thought he had, both stages in the same stroma. Instances do occur in which a stroma is, at the same time, pycnidial and perithecial, and one has to wait until they turn up.

The first definite proof of Massee's theory was provided by Möller*, who found both stages in the same stroma in *Hypocrella cavernosa*. Möller also observed that *Aschersonia basicystis* was similar in shape, etc., to *Hypocrella phyllogena*, and recorded that Lindau had found both stages in the same stroma in specimens sent him from Brazil. Zimmermann† described both stages in *Hypocrella Raciborskii*, and Thaxter‡ has found both in *Hypocrella turbinata*, while during a recent revision of these two genera, both stages have been found in the same stroma in the case of eleven other species.

As I have already stated, 70 species of *Hypocrella* and 60 species of *Aschersonia* have been described. In revising these genera, it has been necessary to make seven new species and to transfer four from other genera. Nevertheless, the total number of valid names is only 54, covering 42 species. In the group parasitic on *Lecanium*, there are at present, 20 species of *Hypocrella*; the corresponding *Aschersonia* is known in eleven cases, and in six of these it has received a name. In the group parasitic on *Aleyrodes*, there are nine species of *Hypocrella*; the

* Phycomyceten und Ascomyceten, 1901.
† *Op. cit., supra.*
‡ Botanical Gazette, LVII, pp. 308–313.

Aschersonia stage of each of these is known, and in six cases it has been named, while there are in addition 13 unattached Aschersonias.

Hypocrella and *Aschersonia* occur on living leaves and stems, on which they form superficial, easily detached stromata. The stromata are usually brightly coloured—white, yellow, red, or brown—and may be subglobose, hemispherical, flattened pulvinate, or scutate. As a rule, they do not exceed 3 mm. in diameter, but one giant from Brazil, *Hypocrella Gartneriana*, is said to attain a diameter of 3 cm. The stroma is composed of thick-walled hyphae and in the species parasitic on *Lecanium* it is usually very hard and sclerotioid. Penzig and Saccardo* instituted the genus *Fleischeria* for the harder species of *Hypocrella*, and, while it is scarcely possible to consider hardness a generic distinction, the name can be associated with a morphological character, as it was applied to a *Hypocrella*, whose *Aschersonia* stage has no paraphyses, whereas in the type species of the genus *Hypocrella*, the *Aschersonia* stage has paraphyses. This sclerotioid character is no doubt to be correlated with the fact that these fungi are superficial, and, not being able to obtain water from the leaf, must be able to withstand periods of drought. It is shared by several other fungi in the tropics which overrun leaves and twigs: the common Thread Blights, for example—white, normal-looking mycelia which occur on the upper parts of bushes and trees—are composed chiefly of sclerotioid hyphae.

One peculiar species, *Hypocrella scutata*, which has been found in Singapore and the Philippines, has a stroma composed chiefly of resin in which the hyphae are embedded. It breaks with a vitreous fracture, and if a lighted match is applied to it it burns like resin. Failing any other explanation, one is led to assume that this peculiarity is due to the insect on which it is parasitic, but it has not been possible to verify that assumption.

In all the collections of *Hypocrella* and *Aschersonia* which I have examined, whenever it has been possible to identify the insect, the latter has belonged to the *Lecaniidae* or to the *Aleyrodidae*. *Aschersonia Coffeae* has been recorded† as occurring on *Aspidiotus*, and *Aschersonia marginata* on *Parlatoria*, but these records are probably erroneous. It is necessary to exercise great caution in deciding what insect a *Hypocrella* is parasitic upon. If a *Lecanium* and a *Lepidosaphes* occur together on the same leaf, a lecaniicolous *Hypocrella* may destroy all the individuals of the *Lecanium*, leaving only the *Lepidosaphes*.

Another ascigerous genus, which occurs on scale insects

* Malpighia (1901), p. 230.

† Journ. Coll. Agric., Tohuku Imp. Univ., Sapporo, v (1913), pp. 73–90.

throughout the tropics, forms black, irregular stromata over or at the side of the scale, and often extending some distance from it. This is *Myriangium*. The stroma is parenchymatous, without true perithecia, but with asci embedded singly in the tissue. The spores are muriform. It was first recorded on scale insects by Zimmermann* in Java in 1901, and has since been found on them in Ceylon, Florida, the West Indies, etc. Some doubt has been expressed concerning the parasitism of this group, because it frequently occurs in company with *Sphaerostilbe*, but the explanation of that would appear to be that it attacks the same species of scale insects as the latter. In many instances it is the only fungus present.

Mr Ramsbottom has pointed out to me that *Myriangium* has been known to be a British genus for more than half a century, though it has not been included in lists or textbooks of British fungi. When Berkeley described the genus†, he stated that it was allied to *Collema*; hence it was at first included among the lichens. Subsequently, it was discarded by the lichenologists, and the mycologists omitted to take it up. Specimens of *Myriangium* were collected in abundance during the Foray on *Chionaspis salicis* on Ash, and effete stromata have been gathered on the same host in Norfolk and Yorkshire.

It is customary to refer the species of *Myriangium* found on scale insects to *Myriangium Duriaei* Mont. and Berk., the type species of the genus, originally recorded in 1845 from the Pyrenees, Algeria and Australia, but the examination of the numerous gatherings of this genus now available has not yet been completed. *Myriangium Acaciae* McAlp. is entomogenous.

Myriangium is generally placed in the *Plectascineae*, in the subfamily *Myriangiaceae*. Von Höhnel‡, who has recently revised the subfamily, considers that the latter should be placed in the *Dothideales*. *Myriangiaceae* has been a convenient centre for little-known genera of doubtful affinities, and von Höhnel has found it necessary to reduce the 23 genera hitherto included in it to five, either by synonymy or exclusion. Apparently 12 species now remain in *Myriangium*. It remains to be determined how many of these are valid, how many are entomogenous, and whether any of the other genera of *Myriangiaceae* which have superficial stromata are entomogenous.

As recorded by Parkin§, a black stromatic fungus, somewhat resembling *Myriangium*, but pycnidial, is found on *Mytilaspis* in Ceylon. It usually has prominent pycnidia, which contain small, brown, narrow-oval spores. Parkin suggested that this

* *Op. cit., supra.* † Hooker's Lond. Journ. Bot., IV (1845), p. 74.
‡ Fragmente zur Mykologie, VI Mitt. (1909), pp. 75–102.
§ *Op. cit., supra.*

is a pycnidial stage of *Myriangium*, but that has not yet been verified.

No species of the *Entomophthoreae* was known on scale insects prior to 1918, when an *Empusa, Empusa Lecanii*, was recorded* on scale insects on coffee in Mysore.

The list of families which are known to provide entomogenous fungi was extended by a remarkable addition in 1907, when von Höhnel† announced his discovery of scale insects beneath the stroma of a *Septobasidium*. That has since been repeated‡ in Ceylon (where all the known species of *Septobasidium* appear to be entomogenous), in Japan, and on specimens from India and Canada.

Species of *Septobasidium* are common in the tropics, where they occur on the stems, and sometimes on the leaves, of living plants, without, as a rule, causing any apparent injury. The commoner species have a peculiar structure. They first cover the stem with a thin adherent stroma, from which arise numerous erect bristles or fascicles of hyphae. Another continuous layer is then developed over the tops of the bristles, so that the structure is two-storied, the upper storey being supported on pillars. The hymenium is developed on the surface of the upper layer. If the fungus is examined in an early stage of development, the remains of the scale insects will be found beneath the initial layer of the stroma. The fungus grows over and kills whole colonies of scale insects, and completely covers the stems of the host plant.

In Ceylon, *Septobasidium rameale* (Berk.) Bres. is frequent on orange trees infested with *Mytilaspis*, sometimes clothing all the stems for a length of several feet and spreading from them over the leaves. A species, allied to *Septobasidium pedicellatum* (Schw.), attacks scale insects on tea, and in some cases covers all the stems of a tea bush. Another species which is found on tea is usually associated with *Chionaspis*. The tea planter is often alarmed when he finds these fungi covering his bushes, but, in general, they are harmless. There are, however, exceptions to the rule. Some species, after destroying the scale insects, attack the plant. That happens in the case of an undetermined species on tea in Ceylon, the species which causes the disease known as Velvet Blight on tea in Northern India, and several species on tea and mulberry in Japan§.

Several species of Hyphomycetes have been recorded as parasitic on scale insects. One of the most interesting of these is a

* Dept. Agric. Mysore, Ento. Series, Bull. 4.

† Sitzungsber. d. Kais. Akad. d. Wissensch. Wien, Math. Naturw. Kl., CXVI (1907), p. 740.

‡ Annals of Botany, XXV (1911), p. 843.

§ Mycologia, X (1918), pp. 88–90.

Fusarium, which was originally described as parasitic on *Aspidiotus Aurantii* in Australia by McAlpine* in 1899 under the name of *Fusarium epicoccum*. Its conidia are variable, sometimes nearly straight, sometimes hook-shaped, but the typical conidium is stout, short, three-septate, and curved to two-thirds of a circle. It was named *Microcera Parlatoriae* by Trabut† in 1907 from specimens on *Parlatoria* on orange in Algeria, *Microcera curta* by Saccardo‡ in 1909 from specimens on a scale insect on *Tilia* in Germany, *Microcera Tonduzii* by Patouillard§ in 1912, from specimens on *Ficus* from Costa Rica, and *Fusarium Aspidioti* by Sawada‖ in 1914 from specimens on *Aspidiotus* on *Pyrus* in Japan. The interesting point about this *Fusarium* is that the short, curved conidium exactly resembles one of the forms of conidia described by Berkeley and Broome as part of *Sphaerostilbe aurantiicola*. It occurs quite commonly with *Sphaerostilbe aurantiicola* in Ceylon, but I have never been able to detect the sporodochium in any of my numerous gatherings of that species. One mounts the ordinary *Microcera* synnema, or an isolated perithecium, and finds the small curved conidium on the slide. It apparently occurs on the slight weft of mycelium at the base of the perithecium. It is abundant in the perithecial specimens collected at Florence in 1860. I was formerly inclined to regard this conidium as typical of *Sphaerostilbe aurantiicola*, but I have found it a specimen of *Sphaerostilbe flammea* from Georgia, Ravenel 3376. The question then arises whether *Fusarium epicoccum* is a stage of *Sphaerostilbe*, or whether the conidia found with the *Sphaerostilbe* are intrusive. Against the first theory, there is the fact that all the collections of the *Fusarium*, with one exception, contain only the *Fusarium*, and the exception is such a mixture that nothing can be deduced from it, as it includes *Sphaerostilbe*, *Pseudomicrocera*, and *Podonectria* on the same leaf. Against the second, we have the absence of any gathering of the *Fusarium* sporodochium from Ceylon.

Another *Fusarium*, *Fusarium coccidicola*, was described by Hennings¶ in 1903 from specimens on tea collected in German East Africa. I have not seen the type, but from the description it would appear to be *Pseudomicrocera*.

A Hyphomycete, which is of considerable economic importance in the Eastern Tropics, was described by Zimmermann** in 1898

* Fungus diseases of Citrus trees in Australia, 1899.
† Bull. Agric. Alger et Tunisie, 1907, p. 32.
‡ Ann. Myc. VII (1909), p. 437.
§ Bull. Soc. Myc. France, XXVIII (1912), p. 142.
‖ Bot. Mag., Tokyo, XXVIII (1914), p. 312.
¶ Engler's Bot. Jahrb. (1903), p. 57.
** Over eene Schimmelepidemie der groene Luizen, Buitenzorg, 1898.

as *Cephalosporium Lecanii*. It is known to occur in Java, Ceylon, and India. In Ceylon, it has been found on several species of *Lecanium*, but it is especially common on *Lecanium viride*, the common scale insect pest of coffee. Indeed, during the rainy seasons, *Lecanium viride* appears to be invariably attacked by this fungus. Recently, it has been found to attack *Icerya Purchasi* in Ceylon, and up to the present it appears to have effectively controlled that insect.

Similarly, *Hyalopus Yvonis* Dop (1905) is said* to have controlled an *Aspidiotus* which was causing great damage to coco-nut palms in Martinique. As *Hyalopus* is not very different from *Cephalosporium*, this species needs comparison with *Cephalosporium Lecanii*.

Other Hyphomycetes which have been found on scale insects are *Acrostalagmus coccidicola* Guéguen (1904) on a coccus on a shrub at the Paris Exhibition of 1900; *Geotrichum coccophilum* Speg., on a coccus on *Cycas revoluta*, Brazil; *Acremonium araucanum* Speg., on *Aspidiotus*, Chili; *Stilbum coccophilum* Sacc., and *Penicillium coccophilum* Sacc., on *Ceroplastes* in the Botanic Garden, Palermo; *Sporotrichum Lecanii* Peck, on *Lecanium* in North America; *Sporotrichum globuliferum* Speg., on *Lecanium hesperidum* at Lisbon†; *Verticillium heterocladum* Penz., on *Lecanium hesperidum* on orange, in Italy. This group has not been critically examined.

In addition to the identifiable fungi enumerated, a number of sterile stromata occur on scale insects. Some of these appear to belong to *Septobasidium*. A small purple red lenticular stroma, which is common in the Eastern Tropics, apparently belongs to *Torrubiella*. Others seem to belong to *Aschersonia*. There is some evidence that these stromata are sterile because they have been attacked by another fungus, e.g. *Cladosporium*, but this phase of the subject is still under investigation. The brown sterile fungus found on scale insects in Florida has been found to be an *Aegerita, Aegerita Webberi*; according to the specimens submitted to me, it is not a state of a *Meliola*.

All the fungi which have been mentioned ultimately make their appearance on the exterior of the scale insects attacked. There is however another class of fungi which are entoparasites. The first of these to be discovered was observed by Leydig in *Lecanium hemisphaericum* in 1854, but their nature was not recognised until 1887 when Monier‡ described *Lecaniascus polymorphus*, parasitic on *Lecanium hesperidum*. During the current century, considerable attention has been given to this group,

* Bull. Scient. France et Belgique, xxxix (1905), p. 135.

† Camara Pestana, J., Bull. Soc. Portugaise Sci. Nat. Lisbonne, ii (1908), pp. 14–18.

‡ Bull. Soc. Zool. France, xii (1887), pp. 150–152.

and about ten species have been described*, parasitic on *Lecanium, Pulvinaria, Aspidiotus, Chermes, Physokermes, Aleurodes, Icerya* and *Dactylopius*. The majority of these belong to the Saccharomycetes. This group is one which invites the attention of British mycologists, as all the existing records have been made in temperate countries—France, Italy, Bohemia, and Germany.

The list of fungi which are parasitic on scale insects is already a long one, but there is every probability that it will be still further extended. The majority of the species are essentially tropical, and when more is known about the biology of tropical fungi, new forms may be expected to be added. From the specimens available in herbaria, these fungi would be considered rare, but it is generally possible, at least in Ceylon, to collect them in large numbers by searching specially for them. I have seen a tree of the Ceylon Patna Oak (*Schleichera trijuga*), on which nearly every leaf bore *Aschersonia placenta*, in some cases so crowded that the stromata had fused into a continuous sheet. The discovery of a single *Aschersonia* usually leads to the collection of dozens, or sometimes hundreds, if the bush is systematically examined, though of course disappointments do occur.

No one who has collected these fungi in the tropics can fail to be impressed by the enormous destruction of scale insects which they bring about. A *Septobasidium* will wipe out all the insects on a badly-infested orange tree or tea bush. *Cephalosporium Lecanii* will attack *Lecanium viride* on coffee over the whole of an estate. I have spent a morning in a Ceylon jungle which consisted almost entirely of Ebony trees, collecting *Aschersonia placenta* on the Ebony leaves, and have not been able to find a single specimen of the Aleyrodid on which it grew: the insect had been obliterated over an area of several acres. Again, in the jungle above Hakgala, *Aschersonia oxystoma* is common on the shrub, *Sarcococca pruniformis*, but although I have collected it there periodically for several years, I have not been able to determine what scale it is parasitic on. When a scale insect on a particular tree is attacked by a fungus, its destruction is so complete that one wonders how the species manages to survive.

Under such circumstances, it is not surprising that attempts have been made to control the scale insect pests of economic plants by means of entomogenous fungi. The best known of these, in fact the only attempts which have been conducted on an experimental basis, have been carried out in Florida, where, since about 1896, the use of *Aschersonia Aleyrodis* and

* See Buchner, Arch. Protistenk. xxvi (1912), pp. 1–116.

Aschersonia Goldiana has been recommended for the control of *Aleyrodes*, and *Sphaerostilbe, Pseudomicrocera*, and *Podonectria* for the control of *Aspidiotus, Lepidosaphes*, etc. For several years, these were regarded as the sole instances of successful control of insects by the use of entomogenous fungi, though adverse criticism was not lacking. Finally, the United States Bureau of Entomology undertook a special investigation into the subject, and the results of four years enquiry and experiment have been published by Messrs Morrill and Back* in a Bulletin entitled, "Natural Control of White Flies in Florida," from which the following extracts are quoted.

"Much damage has resulted in the past from ill-advised attempts to check the spread of white flies in newly infested localities by means of fungus parasites. The control of destructive diseases affecting citrus trees has been interfered with by (these) fungus parasites and much preventable loss thereby incurred. This interference is due to the fear that the fungicides recommended for the diseases referred to, would, if applied to the trees, check the white fly fungus parasites with injurious results.

"Under natural conditions, without artificial assistance in spreading, the fungi have ordinarily in favoured localities, controlled the white fly to the extent of about one-third of a complete remedy through a series of years.

"The most successful method so far devised for introducing the red and yellow Aschersonias into groves where they do not occur is the spore spraying method, first successfully employed and recommended by Dr E. W. Berger. For the introduction of the brown fungus the brushing or dipping and the rubbing methods first used by the authors are as successful as any yet discovered, but are not so reliable as the spore spraying methods for the Aschersonias. The infections secured by artificial means of introducing fungi, while successful in introducing the fungi, have thus far proved of little or no avail in increasing their efficacy after they have once become generally established in a grove. Experiments by the authors, and by citrus growers in co-operation with the authors, involving the treatment of thousands of trees with suitable 'checks' or 'controls' have shown that when fungus (red or yellow *Aschersonia*) even in small quantities is present in a grove there is no certainty that from three to six applications of fungus spores in water solution will result in an increased abundance of the infection on the treated blocks of trees by the end of the season. In some of the most important and carefully planned and executed experiments the fungus has increased more rapidly in sections of

* U.S. Dept. of Agric., Bureau of Entomology, No. 102.

the groves which were not sprayed with spore solutions than in the experimental blocks. In no case has practical benefit been observed to result from efforts to increase the efficiency of the fungi in groves where they previously occurred. The above remarks apply especially to the Aschersonias. With the brown fungus, efforts to increase the efficacy have been equally disappointing from a practical standpoint.

"As a result of the investigations reported herein and of observations and experience covering a period of four years the authors conclude that there are at present no elements of natural control herein dealt with which can be relied upon to give satisfactory results. Under present conditions it is unquestionably more profitable to depend upon artificial remedies."

The Florida results thus agree with those of other experiments of the same character, and at the present day after 30 years' trial there is no instance of the successful control of any insect by means of fungus parasites. If the entomogenous fungi already exist in a given area, practically no artificial method of increasing their efficacy is possible. If they are not present, good may result from their introduction, if local conditions are favourable to their growth, but, on the other hand, their absence would appear to indicate unfavourable conditions.

It would seem that a fungus makes little progress until the insects are excessively numerous, either locally or generally, when for reasons not known an epidemic of fungus disease breaks out. And in this connection it may be noted that the apparently successful experiments in inducing a more rapid dissemination of an entomogenous fungus have usually been made during such an epidemic.

Morrill and Back's statement that *Aschersonia Aleyrodis*, etc., have controlled the white fly to the extent of about one-third of a complete remedy is apparently to be interpreted that an epidemic of fungus disease among the scale insects occurs every three years. Where an insect is always present, these epidemics appear to occur at definite intervals; and where the occurrence of the insect is discontinuous, they appear to occur at a definite period from the first appearance of the insect. The Wilt disease of the Tea Tortrix of Ceylon (*Homona coffearia*), though not a fungus disease, gives a notable illustration of that. The occurrence of that insect as a pest is discontinuous. In the first year of its appearance in any locality, the insect increases without any check; in the second year, Wilt disease attacks a small proportion of the caterpillars; in the third year, it practically kills out every one. In the case of *Cephalosporium Lecanii* on *Lecanium viride* on coffee in Ceylon, an epidemic of fungus disease occurs in the same locality during each rainy season;

in that case the controlling factor is probably climatic. On the other hand, in a small plantation of mulberry trees at Peradeniya, it is always possible to find *Sphaerostilbe aurantiicola* in the rainy season, but only on a few trees, though a large number of trees may be attacked by the same scale insect; in that case, some other than climatic factors must be involved.

The problem which has yet to be solved by those who wish to control insects by means of fungi is how to create an epidemic at a time when such an epidemic would not occur naturally. The evidence indicates that it is not possible to accomplish that by the mere introduction of the fungus or by spraying spores from natural or artificial cultures. The solution of the problem probably depends in each case upon a study of the bionomics of the insect, and it is satisfactory to note that the United States Department of Agriculture has appointed a Myco-entomologist specially to investigate these diseases of insects.

I should like to make my position on this point clear. I do not for one moment wish to deny that it may be possible ultimately to discover what factors govern the incidence of these diseases of insects, and that, in consequence of such discovery, it may be possible to utilise them to control insect pests. But I do hold that, in the present state of our knowledge, after nearly thirty years of investigation and experiment, there are no facts which would warrant the recommendation of any such means of control.

Though the majority of the scale insect fungi are tropical, there is some work to be done on them in the British Isles. We require more material of *Cordyceps pistillariaeformis*, which has occurred on a *Lecanium* on elm. *Sphaerostilbe flammea* is apparently rare in Britain, but it should be sought for in the winter on *Chionaspis salicis* on willow and ash. The insect is especially abundant on ash, coppiced ash in hedge rows being generally badly infested. *Fusarium epicoccum*, not yet recorded as British, should be found in the same situation, and it might be possible to determine its perithecial stage. A *Verticillium* has recently been collected on the same host in Yorkshire; it forms a delicate white mould over the colony of scale insects.

With the exception of the *Cordyceps*, all the scale insect fungi found in Britain have occurred on *Chionaspis*. In the tropics, *Aspidiotus* and *Lepidosaphes* are the favourite hosts of the *Nectria* group, and it should be possible to find species on the common scale insects of fruit trees in Britain, if search is made for them in the winter.